PB81-178303

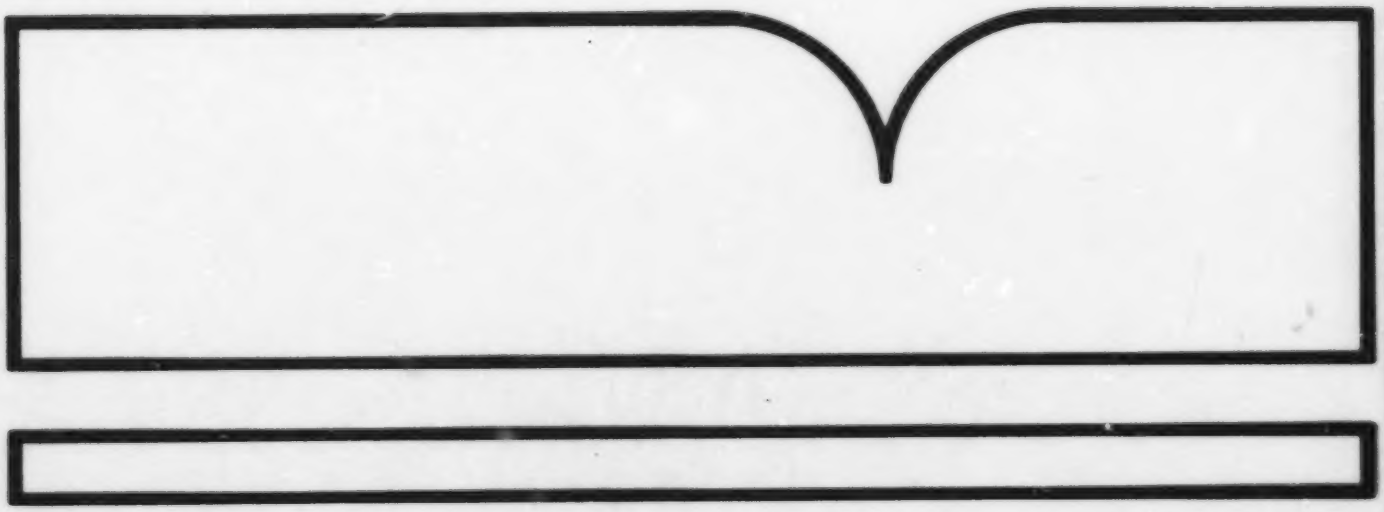
# A Preliminary Feasibility Study for an Offshore Hazardous Waste Incineration Facility

TRW, Inc.
Redondo Beach, CA

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Mar 81



U.S. Department of Commerce
National Technical Information Service
NTIS.

| IERL-RTP-1101a | TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)* | |
|---|---|---|
| 1. REPORT NO. EPA-600/2-81-044a | 2. ORD Report | 3. RECI PB81-178303 |
| 4. A Preliminary Feasibility Study for an Offshore Hazardous Waste Incineration Facility | | 5. REPORT DATE March 1981<br>6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) R.J. Johnson, F.E. Flynn, and P.J. Weller | | 8. PERFORMING ORGANIZATION REPORT NO. |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS TRW, Inc.<br>One Space Park<br>Redondo Beach, California 90278 | | 10. PROGRAM ELEMENT NO. C33B1B<br>11. CONTRACT/GRANT NO. 68-02-3174, Task 19 |
| 12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development<br>Industrial Environmental Research Laboratory<br>Research Triangle Park, NC 27711 | | 13. TYPE OF REPORT AND PERIOD COVERED IERB; 4-6/80<br>14. SPONSORING AGENCY CODE EPA/600/13 |

15. SUPPLEMENTARY NOTES IERL-RTP project officer is David C. Sanchez, MD-62, 919/541-2547. Provided as Problem-Oriented Report to EPA/OWWM. EPA-600/D-80-012 (formerly assigned to this report) has been cancelled.

16. ABSTRACT The report summarizes a feasibility study of using an existing offshore oil platform, being offered to the Government, as a site for incineration of hazardous wastes and related research. The platform, located in the Gulf of Mexico about 100 km south of Mobile, AL, has potential as an environmentally safe site for operational and research oriented incineration. The study indicates that an incinerator, capable of destroying a wide range of waste types at up to 3 metric tons/hour, can be installed on the platform along with the necessary support facilities. An environmental assessment of worst-case air and water quality impacts from waste incineration revealed insignificant air quality effects at the nearest land point and on the platform. Water quality effects will not be significant for most wastes. For highly toxic and persistent substances, an activated carbon scrubber water treatment system can be provided. Estimated capital costs were $6.6 million for offshore and shore base facilities, and waste transportation containers. Labor, offshore personnel subsistence, fuel, transportation, maintenance, depreciation, and land lease costs were estimated at $3.9 million/year, or approximately $298/metric ton of waste incinerated for 12 hour/day, 7 days/week operation. Continuous and intermittent operation of the incinerator were also considered.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|---|
| Pollution | Activated Carbon | Pollution Control | 13B |
| Offshore Structures | Scrubbers | Stationary Sources | 13M 07A,13I |
| Incinerators | | At-Sea Incineration | |
| Waste Disposal | | Hazardous Wastes | |
| Toxicity | | | 06T |
| Hazardous Materials | | | 11G |

| 18. DISTRIBUTION STATEMENT | 19. SECURITY CLASS *(This Report)* | 21. NO. OF PAGES |
|---|---|---|
| Release to Public | Unclassified | 34 |
| | 20. SECURITY CLASS *(This page)* Unclassified | 22. PRICE |

EPA Form 2220-1 (9-73)

PRODUCT OF:
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA 600/2-81-044a
March 1981

# A PRELIMINARY FEASIBILITY STUDY FOR AN OFFSHORE HAZARDOUS WASTE INCINERATION FACILITY

## SUMMARY REPORT

by

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Contract No. 68-02-3174
Work Assignment No. 19, TSA 3-7

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## ABSTRACT

This report summarizes the results of a feasibility study of using an existing offshore oil platform as a site for incineration of hazardous wastes and related research. Chevron U.S.A., Inc. has offered to transfer this platform, Main Pass Block 254 "A" Structure, to the Federal Government. The platform, located in the Gulf of Mexico approximately 100 km. south of Mobile, Alabama, has potential as an environmentally safe site for operational and research oriented incineration activities. Results of the study indicate that a rotary kiln incinerator with a high temperature afterburner, capable of destroying a wide range of waste types at up to 3 metric tons/hour, can be installed on the platform along with the necessary support facilities. An environmental assessment of worst case air and water quality impacts from waste incineration revealed insignificant air quality effects at the nearest land point and on the platform. Water quality effects will not be significant for most wastes. For highly toxic and persistent substances, an activiated carbon scrubber water treatment system will be provided. Estimated capital costs were $6.6 million for offshore and shore base facilities, and waste transportation containers. Labor, offshore personnel subsistence, fuel, transportation, maintenance, depreciation, and land lease costs were estimated at $3.9 million/year, or approximately $298/metric ton of waste incinerated for 12 hour/day, 7 days/week operation. Continuous and intermittent operation of the incinerator were also considered.



This report was submitted in partial fulfillment of Contract No. 68-02-3174, Work Assignment No. 19, Technical Service Area 3-7, under the sponsorship of the U.S. Environmental Projection Agency. This report covers the period April 13, 1980, to June 13, 1980.

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# 1. INTRODUCTION

Chevron U.S.A., Inc. has offered to transfer an offshore oil platform, Main Pass Block 254 "A" Structure, to the Federal Government. This platform, constructed in 1975 at a cost of $11,587,000, is located in the Gulf of Mexico approximately 100 kilometers (60 miles) south of Mobile Point, Alabama, and 120 kilometers (75 miles) east of North Pass, Louisiana. The U.S. Environmental Protection Agency (EPA) and the U.S. Coast Guard (USCG) have made a preliminary determination that the platform has potential as a site for installing a high temperature incinerator for use in the disposal of hazardous material, including wastes resulting from cleanup operations. The evaluation took into account the necessity to destroy highly toxic waste at a location with minimum risk to public health and the environment, the need for further research on thermal destruction of hazardous waste, and the cost advantages of at-sea incineration.

This report summarizes the results of an evaluation of the technical and environmental feasibility of using the proposed offshore platform as an incineration facility for destruction of hazardous wastes and for incineration research (Reference 1). Specific objectives of the study were:

- Identify EPA/USCG hazardous waste disposal and research needs.
- Evaluate existing hazardous material incineration systems.
- Design a conceptual incinerator system based upon existing commercially available hazardous waste incineration systems.
- Prepare a monitoring plan, systems operation plan, and cost estimates for the conceptual incineration system.
- Develop requirements, conceptual design, and cost estimates for offshore and shore base support facilities, and for a multimodal container for transporting hazardous material.
- Estimate the environmental effects on air and water quality from incineration of hazardous materials at the offshore platform site.

Information regarding hazardous waste disposal and research needs was obtained from EPA, USCG, and the literature. A subcontract was issued to TerEco Corporation to provide a marine environmental assessment for the offshore site (Reference 2). Major results of the assessment are summarized in this report. A preliminary evaluation of the platform structure has been performed by the USCG (Reference 3).

## 2. FINDINGS AND CONCLUSIONS

Results of this study have demonstrated the basic technical and environmental feasibility of the proposed offshore platform for use as a hazardous waste incineration site. In addition, investigations undertaken as part of this study indicated the critical national need for an environmentally safe location for operational destruction of highly toxic substances and incineration research. Bases for these conclusions are:

- Information obtained from EPA, USCG, and the literature revealed requirements for incineration of hazardous materials and waste combustion research that are more environmentally acceptable at an offshore site than at land-based facilities.

- Evaluation of both commercial and EPA developed incineration systems indicate that a rotary kiln coupled to a high temperature liquid injection afterburner is the most versatile system for thermal destruction of a wide variety of waste types.

- A conceptually designed rotary kiln/afterburner incineration system, based upon commercially available, performance-proven components, can be installed and operated on the proposed ocean platform. Maximum design feed rates are 3.0 metric tons/hour of liquids and pumpable slurries, or 1.5 metric tons/hour of solid material.

- Although the platform deck area is limited, conceptual design of the offshore support facility has shown that all required subsystems, including life support systems and container handling, can be accommodated (See Figure 1).

- A preliminary evaluation of the platform by the USCG in 1978 found the structure to be probably structurally adequate and in good condition. Structural analysis and testing were recommended before assumption of ownership by the Federal Government.

- A shore base facility was conceptually designed to meet all requirements for waste handling and storage, and standard commercially available containers were identified for transporting liquid and solid waste materials.

- Estimated environmental effects on air and water quality from incineration of typical hazardous wastes indicated insignificant air quality impact at the nearest land point. Air quality degradation on the platform itself is considered unlikely because of structural and meteorological conditions. Water quality effects from quench/scrubber effluents will not be significant for most wastes. For highly toxic and persistent substances, an activated carbon scrubber water treatment system will be utilized as required.

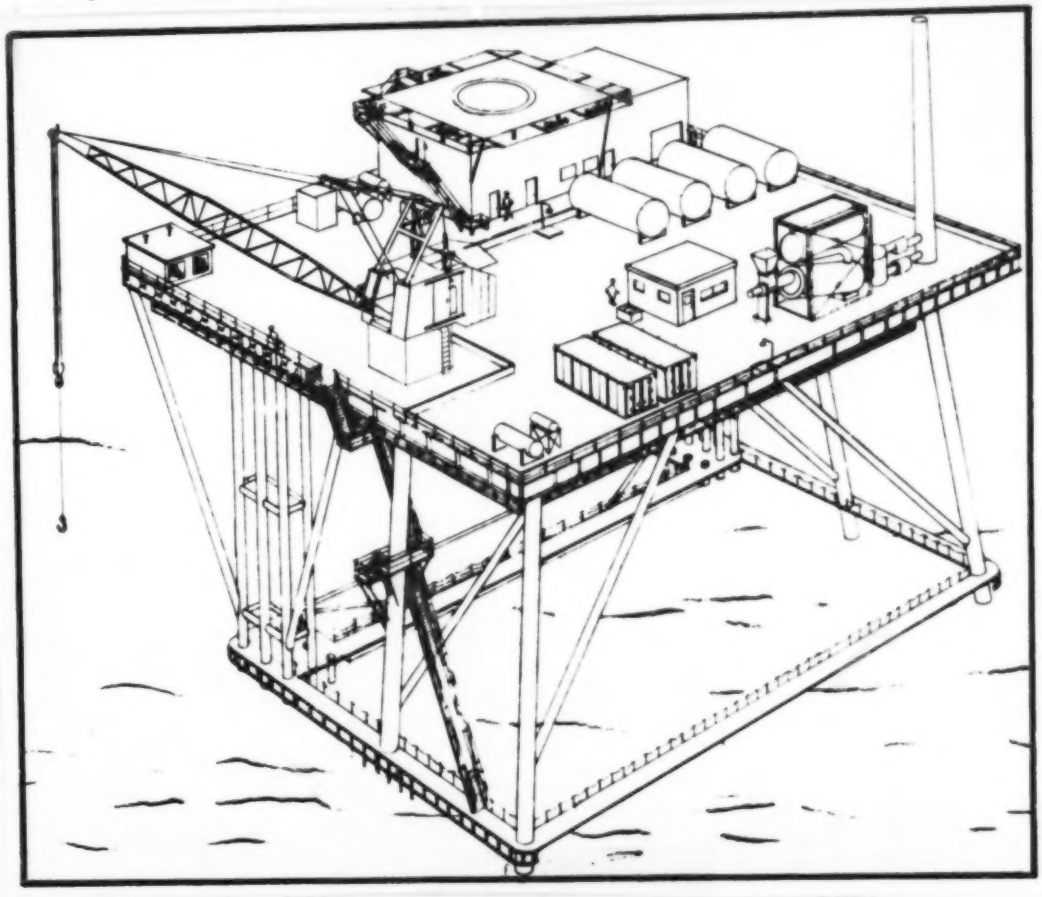

Figure 1. Proposed Offshore Incineration Platform

Cost estimates for the conceptual incineration system and support facilities are summarized in Table 1. Current list prices of commercially available equipment and components were used whenever applicable. Installation costs of systems can only be considered as rough estimates because of uncertainties in labor costs and potential delays inherent in offshore operations. All costs are given in October 1979 dollars and must be adjusted for future procurement and construction time periods.

TABLE 1. SUMMARY OF ESTIMATED CAPITAL COST - INCINERATION SYSTEM AND FACILITIES

| | |
|---|---|
| Incineration System | $3,239,000 |
| Offshore Support Facility | 2,095,900 |
| Shore Based Facility | 647,700 |
| Multimodal Waste Containers | 276,900 |
| Miscellaneous Equipment | 43,400 |
| Transportation of Equipment to Platform | 257,800 |
| TOTAL | $6,560,700 |

Yearly operating costs for the offshore platform and onshore facilities are listed in Table 2. These costs do not include cost of insurance.

TABLE 2. YEARLY OPERATING COST ESTIMATE - OFFSHORE AND SHORE BASED FACILITIES

| | | | |
|---|---|---|---|
| Offshore Platform | | | |
| Labor | 12 persons, 12 hrs/day, 7 days/week | $ 960,000 | |
| Subsistence | 12 persons, 365 days | 53,000 | |
| Fuel | 890,000 gallons of diesel oil | 801,000 | |
| Transportation | waste, fuel, supplies | 156,000 | |
| | helicopter service | 52,000 | |
| Maintenance | 12% of equipment costs | 520,300 | |
| Depreciation | 20% of equipment costs | 867,100 | |
| | 10% of building costs | 72,700 | |
| | Total | | $3,482,100 |
| Shore Based Facility | | | |
| Labor | 8 persons, 260 days | $ 297,000 | |
| Maintenance | 8% of equipment costs | 20,000 | |
| Depreciation | 20% of equipment costs | 50,100 | |
| | 5% of building costs | 6,300 | |
| Land Lease | including dock use | 57,600 | |
| | Total | | $ 431,000 |
| Total Yearly Operating Costs (without insurance costs) | | | $3,913,100 |

Insurance cost is not included in this estimate for two reasons: 1) if the Federal Government assumes liability, no insurance cost is involved; 2) if a contractor must obtain insurance, the cost will vary greatly depending upon many factors not defined at this time and may exceed all other operational costs combined. Liability insurance coverage may cost $3 to $6 million/year, according to one consultant contacted. Estimates of insurance costs may be obtained when more detailed requirements can be specified.

At the maximum waste feed rate of 3 metric tons/hour for 12 hours/day, 7 days/week, the total offshore platform and land based facility operating cost of $3.9 million/year is an average of $298/metric ton, without insurance cost. Yearly operational costs would increase by approximately $2 million for 24 hour/day incineration because of additional labor, subsistence, fuel, and transportation costs. However, with other costs remaining essentially the same, operating costs per metric ton of waste incinerated would decrease to approximately $225 for continuous operation of the incinerator. Intermittent operation for waste destruction or research burns (e.g., two weeks on, two weeks off) would reduce operating costs to approximately $2.9 million per year, but increase costs per metric ton of waste to over $440.

Cost of diesel oil for auxiliary fuel may be reduced by use of high heat content wastes for incineration of wastes which do not sustain high temperature combustion. Utilization of gas or oil provided by tapping reserves at the platform site was considered, but use of diesel fuel was assumed because existing wells are plugged and also contain $H_2S$. Diesel oil will also be used for power generation and decontamination of waste containers (rinse fluids will be burned as auxiliary incineration fuel).

The conceptual designs of the incineration system and support facilities prepared for this study evidence the technical feasibility of the proposed offshore incineration platform, and serve as a basis for initial cost estimates. Results of the preliminary environmental assessment indicated only minor air and water impacts from incineration of typical hazardous wastes. However, for highly toxic and persistent wastes, a more rigorous analysis should be made. This would require more detailed meteorological and marine data for the specific site than is presently available.

## 3. NEED FOR OFFSHORE INCINERATION PLATFORM

During the past several years, it has become increasingly difficult to dispose of oil and hazardous substances resulting from cleanup of accidental or intentional spills and abandoned waste sites. Greater public awareness of hazardous substance disposal dangers have led to actions by many state and local governments to more closely control or eliminate existing landfill disposal areas and incineration facilities. For example, a model secure landfill in Illinois was closed by court order in 1978 after residents of the area learned that waste containing PCBs from a cleanup operation in Missouri had been disposed of there. At the time, there was no alternative to landfill disposal of these wastes; incineration of PCB-containing wastes on an offshore platform would provide an alternative to land disposal. Construction of new facilities on land creates serious public opposition because even remote land sites are viewed as a long term danger.

Although there are many other methods of waste disposal that may be employed (i.e., containerization and storage, deep well injection, ocean dumping, and landfill), high temperature incineration is recognized as an effective means of total destruction of many highly toxic wastes. Incineration of wastes eliminates any long term risk to the public health and environment, and also eliminates the costs associated with future monitoring and liability. About one-half of the annual output of hazardous waste is organic and amenable to incineration. Incineration of hazardous wastes can be conducted at a land-based site, at sea on a specially constructed or modified vessel, or on a structure located offshore.

A telephone survey conducted by EPA in August, 1979, indicated that there are less than 30 commercially available land-based hazardous waste incinerators in the United States. Continued operation of some of these incinerators is threatened by mounting public opposition. An EPA proposal to construct a small pilot scale incinerator in a rural area of Virginia to conduct research on hazardous waste incineration met with such strong public opposition that those plans were cancelled. Several other locations were explored with similar results.

At-sea incineration onboard ships has been employed since 1969 by German and Dutch firms. Three specially equipped German tankers, the Matthias I, II, and III, have been used for high temperature incineration in the North Sea. The Matthias II is still in service. A Dutch vessel, the M/T Vulcanus, has been incinerating European wastes since 1972, and also has been successfully used under permit from EPA to incinerate organochlorine wastes in the Gulf of Mexico and Herbicide Orange in a remote area of the Pacific Ocean. However, the Vulcanus and Matthias II can only handle pumpable liquid wastes of sufficient caloric value to insure complete thermal destruction. Although incineration at sea on a vessel is less costly on a per-unit basis than land-based incineration because scrubbers to control emissions are not usually required at sea, the limited availability of a vessel and restrictions on the types of wastes that can presently be handled are disadvantages.

While there are no incineration facilities presently located on an offshore platform, such a facility would have the advantages associated with at-sea incineration: 1) remoteness from populated areas and (2) less cost than land-based incineration because the environmental controls can be based upon proximity to land and on meteorological and oceanographic conditions. By using more than one type of incinerator (liquid injection and rotary kiln) on the offshore platform, the range of waste materials that can be handled may be broadened to include solids and slurries as well as liquids. The major disadvantage of offshore incineration is the transportation requirement from the nearest port to the platform.

An offshore incineration platform could be used for the thermal destruction of industrial hazardous wastes, pesticides, toxic material and oil spills, as well as drums of contaminated soil and debris. Nearly all pesticides are decomposed by high temperature incineration including the persistent or multi-chlorinated hydrocarbons such as DDT and 2,4,5,-T. Incineration could dispose of 1.2 million gallons of the recently banned silvex-containing herbicides. Other incinerable materials that would be candidates for disposal at the offshore platform are organic solvents and monomers such as acetone, benzene, toluene, formaldehyde, acrylonitrile,

phenol, styrene monomer, xylene, ethylene dichloride, and methyl alcohol, all of which have been involved in spills in recent years. The platform could be utilized for incineration of large quantities of waste or small batches to suit EPA and USCG needs.

Data gathered by the USCG Pollution Incident Reporting System (PIRS) indicates that only a small fraction of the substances spilled are recovered. Most of the spill becomes mixed with soil or water, increasing the volume to be disposed. Contaminated soil, wood, and debris would be candidates for offshore incineration along with the spilled material. No trends are evident in the amount or type of material spilled each year from the PIRS data. However, the data indicate that 5.3 million gallons, or 69% of the 7.7 million gallons of hazardous material spilled during 1975-1978, were located in the Gulf of Mexico and neighboring states. An increasing proportion of the total volume of material spilled occurred in this area each year: 18% in 1975, 27% in 1976, 67% in 1977, and 94% in 1978. A Gulf site would therefore be advantageous for an operational incinerator facility to minimize the transportation of the hazardous wastes.

In addition to providing a facility for operational destruction of hazardous wastes in a location minimizing the risk to public health, the offshore platform would also be a safe site to continue EPA's research into hazardous waste incineration. Trial burns of hazardous materials not previously incinerated could be conducted to establish optimum incineration parameters, determine destruction efficiency, identify combustion products, and monitor emissions. Based upon these test results, suitability for incineration on land or at sea could be determined.

The following is a list of some of the operational uses and research needs which the proposed offshore incineration facility could serve:

- Dispose of material containing hazardous constituents from spills, dump sites, etc.
- Conduct incineration tests to establish conditions for safe disposal of specific wastes.
- Investigate the thermochemistry of many hazardous compounds not presently characterized.

- Perform mathematical modeling of large-scale incinerators.
- Evaluate effects of operational upsets on waste destruction efficiency and plant and personnel safety.
- Investigate toxic product generation by incineration and fate of these products (ash, flue gas, etc.).
- Perform corrosion studies with different types of wastes, their products, and materials.
- Evaluate the performance of air-pollution control equipment for toxic organics.
- Perform incinerator instrumentation and process control research, and systems safety analyses.
- Collect economic data for incineration of various materials.

# 4. OFFSHORE INCINERATION SYSTEM

In order to select an incinerator design for the offshore platform, an evaluation was made of existing systems capable of incinerating hazardous materials. Both commercial and EPA developed systems were investigated during this study. It was concluded that a rotary kiln in conjunction with a liquid injection incinerator (used as an afterburner) represents the most versatile combination for thermal destruction of a wide variety of waste types. The rotary kiln utilizes mechanical mixing which permits the solid or liquid wastes to be exposed to hot oxidizing gas for as long as needed for their destruction. This incinerator is particularly well-suited for the destruction of solids and highly viscous sludges, including wastes resulting from cleanup of spills. The liquid injection incinerator also offers excellent mixing so that vaporized waste can be effectively destroyed. Consequently, a rotary kiln with a liquid injection afterburner was selected as the offshore incinerator for this feasibility study.

## 4.1 CONCEPTUAL DESIGN

Design criteria for the conceptual incineration system were:

Feed rates - 0.5 to 1.5 metric tons/hr of solid material or 1.5 to 3.0 metric tons/hr of liquids and pumpable slurries.

Shredder - capable of processing solid wastes, 55 gallon drums, soft metals, fence posts, etc.; enclosed to control fumes.

Rotary kiln - operating temperature of 1000 to 1300°C, up to 1 hour solids residence time, negative pressure to minimize fugitive emissions.

Afterburner - operating temperature of 1300 to 1500°C, above 2 seconds gas residence time, 3% $O_2$ or greater (exceeds Federal Regulation requirements for incineration of PCBs), negative pressure.

Quench section - seawater injected to cool combustion gases to 300°C, allowing use of standard materials and bearings for induced draft fan.

Scrubber section - single pass seawater scrubber used only when adverse meteorological conditions occur during incineration of highly toxic wastes, or for selected research burns.

Effluent water treatment system - activated granular carbon is used to treat quench/scrubber effluents when required. The spent carbon is regenerated in the rotary kiln between incinerator operations.

Induced draft fans - used to provide combustion gas flow through the incineration system and maintain negative pressure to minimize fugitive emissions.

Exhaust stack - combustion gases from the incinerator will be exhausted through a 15 meter (50 ft) high stack to preclude "down-wash" of the plume.

Control/data acquisition system - both incinerator process control functions and data acquisition will be performed by a single digital computer system. Process controls will incorporate safety interlocks, programmed start-up and shutdown cycles, and warning alarms. Combustion efficiency will be continuously calculated and displayed along with all process parameters and air pollutant monitoring data. Data can be transmitted directly to shore based facilities.

The incineration system design selected for the offshore platform is shown schematically in Figure 2. The basic incinerator selected is the Bartlett-Snow "Tumble Burner," Model #12, manufactured by Combustion Engineering, Inc. This size unit is used for incineration of chemical wastes at a number of industrial plants and waste disposal facilities. As shown in Figure 2, solid wastes are shredded and fed into the rotary kiln. Fumes from the shredder enclosure also pass into the kiln. Pumpable liquid wastes can be fed into either the kiln or the afterburner, along with auxiliary fuel as required to supplement the heat content of the waste material. After cooling by the quench section, combustion gases are normally ducted directly to the exhaust stack, but may be diverted through the scrubber when required for environmental safety considerations or research needs. Quench/scrubber effluents are released below the surface of the sea, either directly or after treatment by an activated carbon system when needed to protect the local marine environment.

## 4.2 MONITORING PLAN

The goal of monitoring the offshore incineration activities is to provide information needed for predicting, maintaining, and documenting conditions for the safe disposal of the waste materials and for the protection of personnel and the environment. To accomplish this, the monitoring plan includes the following activities:

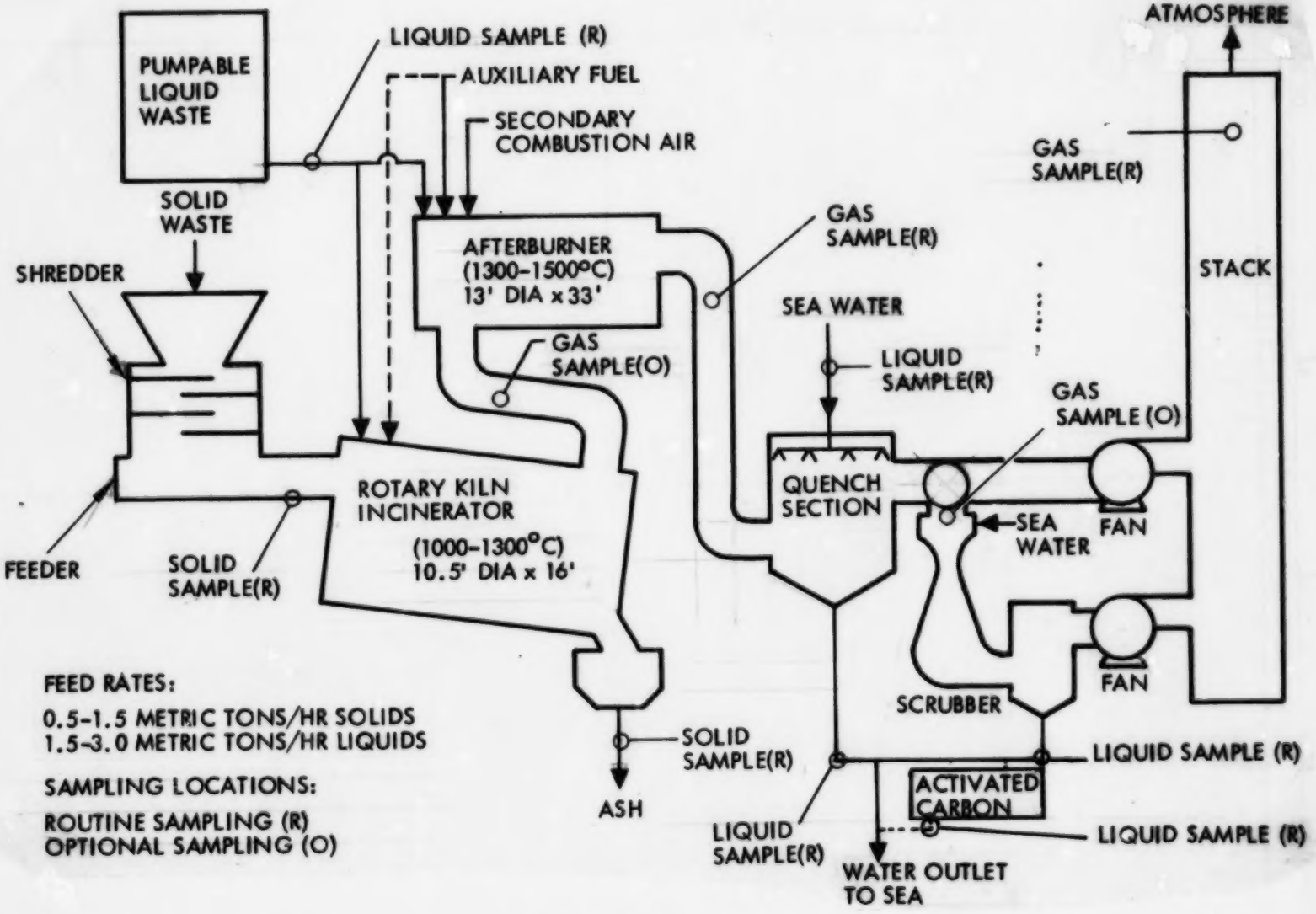


Figure 2. Conceptual Incineration System Schematic

- Waste feed characterization
- Combustion efficiency determination
- Waste destruction efficiency determination
- Emission and effluent pollutant measurements
- Storage and work area contaminant measurements
- Meteorological and oceanographic measurements.

Monitoring will begin with the acquisition of a representative sample of the waste material at the waste generation or spill site. Analysis of this sample at the shore based support facility will determine handling and combustion requirements. During incineration, various indicators of combustion efficiency will be monitored by on-line gas analyzers, and samples will be collected for laboratory analyses to determine waste destruction efficiency (see Figure 2 for sampling locations).

On-line gas analyzers and collected samples will also be used to monitor pollutants in the final air emissions, liquid effluents, and solid residue from the incineration system. The potential introduction of contaminants into the storage and work areas from fugitive and other inadvertent sources will be monitored. Because of the close proximity of the crew's living quarters to the waste storage and incineration areas, monitoring for the introduction of contaminants into the quarters will also be needed. For personnel safety, as well as for the protection of the platform structure itself, meteorological and oceanographic conditions (such as wind speed and direction) will be monitored to prevent undesirable exposure to toxic or corrosive emissions.

The foregoing monitoring activities require specialized equipment and facilities which will involve both the shore based support facility and the offshore platform. In general, the shore based facility will be equipped to perform the more sophisticated, detailed analyses on collected samples, while the offshore facility will perform on-line measurements and quick-response type analyses.

Most of the data resulting from the monitoring activities will be handled by the platform facility's computer. Direct measurements by monitoring instruments will be digitized for interfacing directly with the

computer. Visual observations and data resulting from laboratory analyses will be entered manually. The computer will then store, reduce, and analyze the raw data. Outputs will include information needed by the platform facility operators, complete reports of raw or reduced data, and transmissions to the shore based support facility.

## 4.3 SYSTEMS OPERATION PLAN

The objective of the systems operation plan is to identify and plan in logical sequence all activities necessary in the operation of the offshore incineration platform for destruction of hazardous waste. The plan is developed in terms of the sequential flow of activities and decision points dictated by the incineration process requirements and by constraints imposed for safety and environmental protection.

Four sequential operations take place in any waste disposal action:

- Waste collection and preparation
- Waste transportation
- Waste disposal
- Waste container/equipment decontamination.

In the waste collection and preparation steps, all actions are initiated to develop a safe and reliable disposal. The information needed to do this is obtained by an initial general identification of the waste and circumstances surrounding the waste disposal action, and from actual analysis of waste samples. This information dictates actions necessary to comply with existing regulations on incident reports and transportation, records, etc., as well as to determine safe containers, incineration conditions, and handling.

In the waste transportation steps, the logistics of actual movement of waste, usually first to an incinerator staging area and then to the platform itself, are identified.

In the waste disposal steps, the delivery of the waste from its container to the incinerator, processing of the waste in the incinerator, and monitoring/operation conditions associated with the waste disposal are covered. Disposal of any solid waste resulting from the incineration or

associated procedures is also covered in this sequence.

In the final step, which may occur only at intervals, the incineration equipment and salvageable waste containers are decontaminated for renewal of the cycle. In the case of equipment, this covers procedures to be followed prior to shutdown, repair maintenance, or change to a different waste or incineration condition. In the case of salvageable waste containers, this includes any treatment prior to return to the staging area for reuse.

## 4.4 COST ANALYSIS

Cost estimates for the incineration system are based upon list prices of commercially available equipment which comprise the major components of the system. These prices were effective during October, 1979. Installation costs of the system are estimated to a rough order of magnitude because of uncertainties in labor costs and potential delays inherent in offshore operations.

Estimated costs of the offshore incineration system components and installation are:

| | |
|---|---|
| Combustion Engineering, Inc., "Tumble Burner," Model #12, including rotary kiln, refractory, feeder, afterburner, and scrubber | $ 670,000 |
| Saturn Manufacturing, Inc., Model 62-32 shredder, including electric motors and hydraulic drive unit | 64,000 |
| Monitoring Instrumentation, including gas conditioners, gas analyzers, recorders, sampling equipment, and meteorological and oceanographic instrumentation | 125,000 |
| PDP-1134A Digital Computer System, including data storage unit, typewriter, video display, high speed printer, and software | 120,000 |
| Activated carbon scrubber water treatment system, including filtration tank, carbon contactor, and granulated carbon | 760,000 |
| Installation of above components, including transportation, erection, wiring, plumbing, auxiliary equipment such as exhaust stack, quench and scrubber water discharge piping, etc. | 1,500,000 |

Note: Not included are support buildings, basic foundation, utilities, fuel tanks, and crane for erection (all included in support facilities estimates)

| | |
|---|---|
| Total estimated cost | $3,239,000 |

# 5. SUPPORT FACILITIES

The support facilities required for the proposed offshore hazardous waste incineration system are:

- Offshore platform facility
- Shore based facility
- Multimodal waste containers

## 5.1 OFFSHORE FACILITY

The existing offshore platform is capable of accommodating the necessary subsystems, as shown in Figure 3, including the incinerator and control center, storage and decontamination areas, safety and life support equipment, and crew quarters. Berthing and mess facilities are designed for 20 persons, including 2-3 visitors. Workshop and laboratory areas are also provided.

Layout of equipment on the platform is dictated by operational and safety considerations. The incinerator is located on the downwind corner of the platform (under usual meterological conditions). A dike is provided to contain spills and protect the living quarters. The life support systems are designed to marine or offshore industry standards. Electrical power is supplied by a redundant diesel generator system. Diesel oil is also used as auxiliary fuel for the incinerator when required.

Material handling is performed by the crane, supplemented by a fork truck. Waste transportation and supply vessels will moor alongside the platform for unloading.

Estimated costs of the offshore facilities are:

| | |
|---|---|
| Building, Living Quarters - 3330 S.F. at $185/S.F. | $ 616,000 |
| Control Center - 225 S.F. at $50/S.F. | 11,300 |
| Helipad | 100,000 |

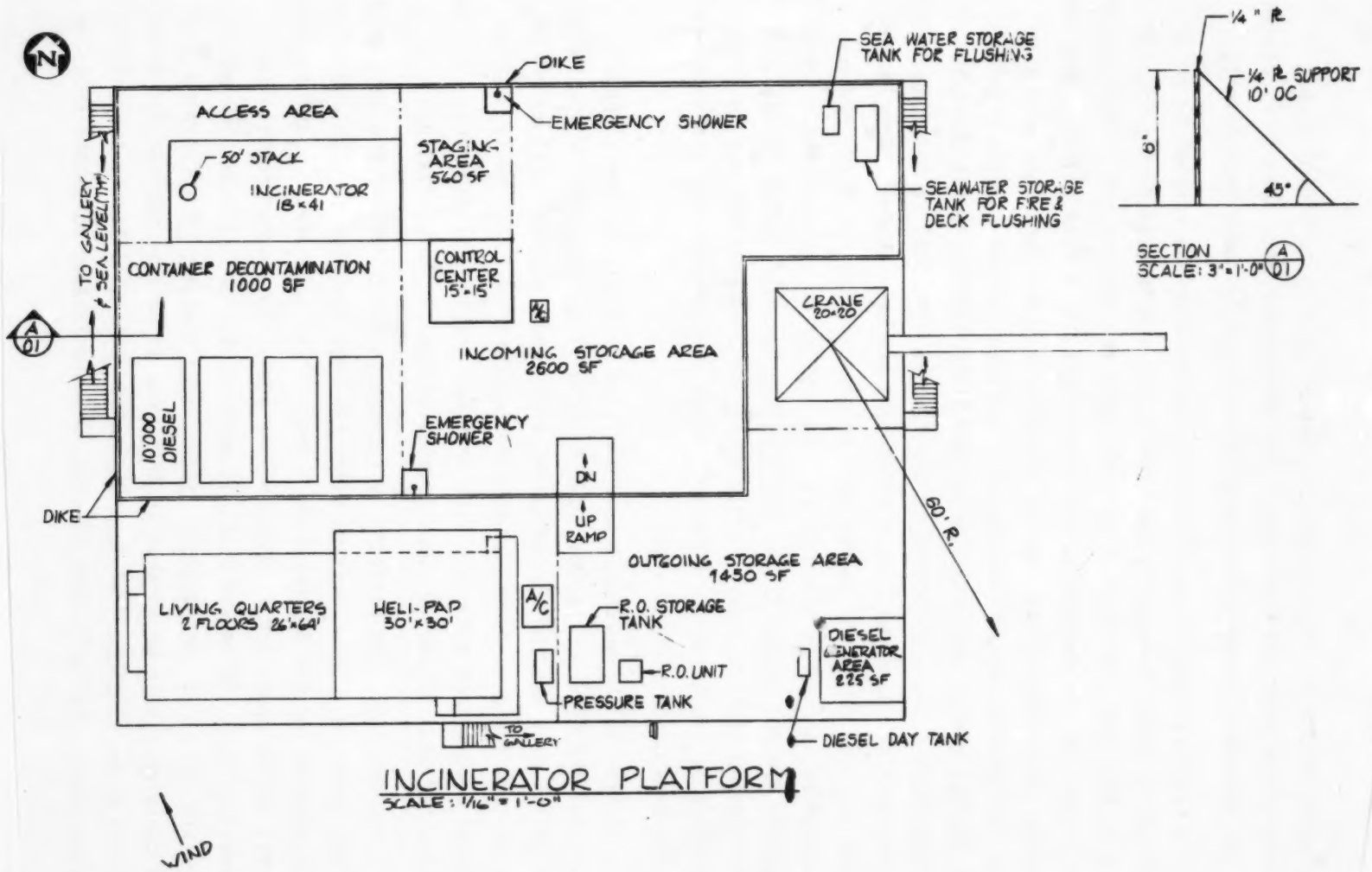


Figure 3. Offshore Platform Plan View

| | |
|---|---|
| Mechanical and Electrical Subsystems | $ 636,500 |
| Crane (Boom Type, Capacity 10 tons at 100 feet) | 460,000 |
| Structural Work | 12,500 |
| | $1,836,300 |
| Overhead, Profit, Contingency and Engineering on Subsystems and Structural Only | 259,600 |
| Total Estimated Cost | $2,095,900 |

## 5.2 SHORE BASED FACILITY

Figure 4 is a plan view of a proposed shore based support facility. No specific site has been selected, therefore the layout is representative of a site that may be located adjacent to a port near the offshore platform. A key requirement for such a site is that it be close to all transportation modes yet be at a safe distance from populated areas. The shore base also serves as a storage buffer area for the offshore incineration facility, which has a very limited storage capacity.

Safety considerations include a dike enclosing the container staging area. The support building contains offices, a laboratory for chemical analyses, and a truck and rail car loading dock. Close proximity to a ship loading dock is a requirement for selecting a facility site. Most materials are assumed to be delivered by truck; however access to a railroad siding is also desirable.

Estimated costs of the shore based facilities are:

| | |
|---|---|
| Site Preparation - 3.7 acres | $ 5,900 |
| Paving - Asphalt | 14,100 |
| Concrete | 28,100 |
| Railroad Siding - 210 feet | 8,500 |
| Fence - 1,600 feet | 14,700 |
| Building - 5000 S.F. | 125,000 |
| Heating, Ventilating, and Air Conditioning | 5,700 |

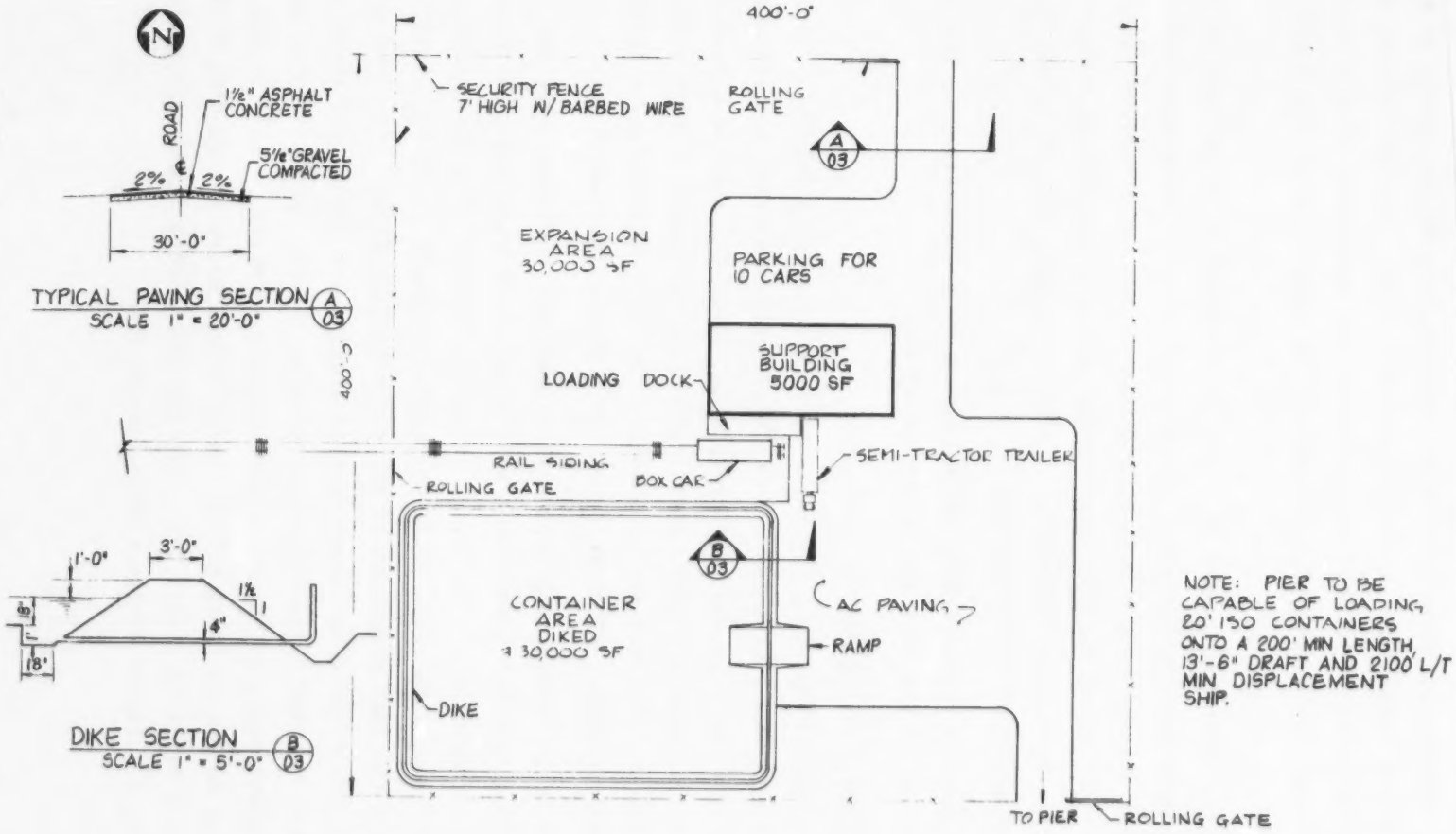


Figure 4. Shore Based Support Facility Layout

| | |
|---|---|
| Electrical | $ 35,000 |
| Subsystems | 9,700 |
| Laboratory Equipment | 200,000 |
| | $446,700 |
| General Contractor's Overhead and Profit (25%), Contingency (10%) and Engineering (10%) | 201,000 |
| Total Estimated Cost | $647,700 |

## 5.3 MULTIMODAL CONTAINERS

The objective of this part of the study was to conceptually design and cost a multimodal container for hazardous wastes. To load material at a remote site, move it over rail or highway, and eventually load it aboard a ship for transport to the incineration platform requires a container that is capable of safe, routine handling at every transfer point. The International Standards Organization (I.S.O.) container was initially considered for this application because it was designed specifically for intermodal use. As the study progressed, it became evident that there could be problems in handling large (8' x 8' x 20' is the common size) I.S.O. containers at the platform, in addition to the more serious handling problems at a "nonpredetermined" spill site.

The proposed container system consists of 60 dry bulk material containers (BMC's) and 350 liquid BMC's. Capacity of each BMC is 440 gallons. A tilt fixture (Fig. 5) is used for gravity feed of solid wastes to the shredder and incinerator. An air tight seal is maintained between the container and tilt fixture. Liquid wastes are fed by a pump and manifold system. Handling devices to interface with BMC's are routine; forklifts transfer them on the platform and during transit. Crane attachments are made by lugs designed for the purpose. Containers can be stacked two or three high during storage.

Estimated costs of the selected containers are:

| | |
|---|---|
| Dry Materials: | |
| Tote Systems No. S-90, 60 at $789 each | $47,300 |

| | |
|---|---|
| Liquid Materials: | |
| Tote Systems No. S-549, 350 at $656 each | $229,600 |
| Total Estimated Cost | $276,900 |

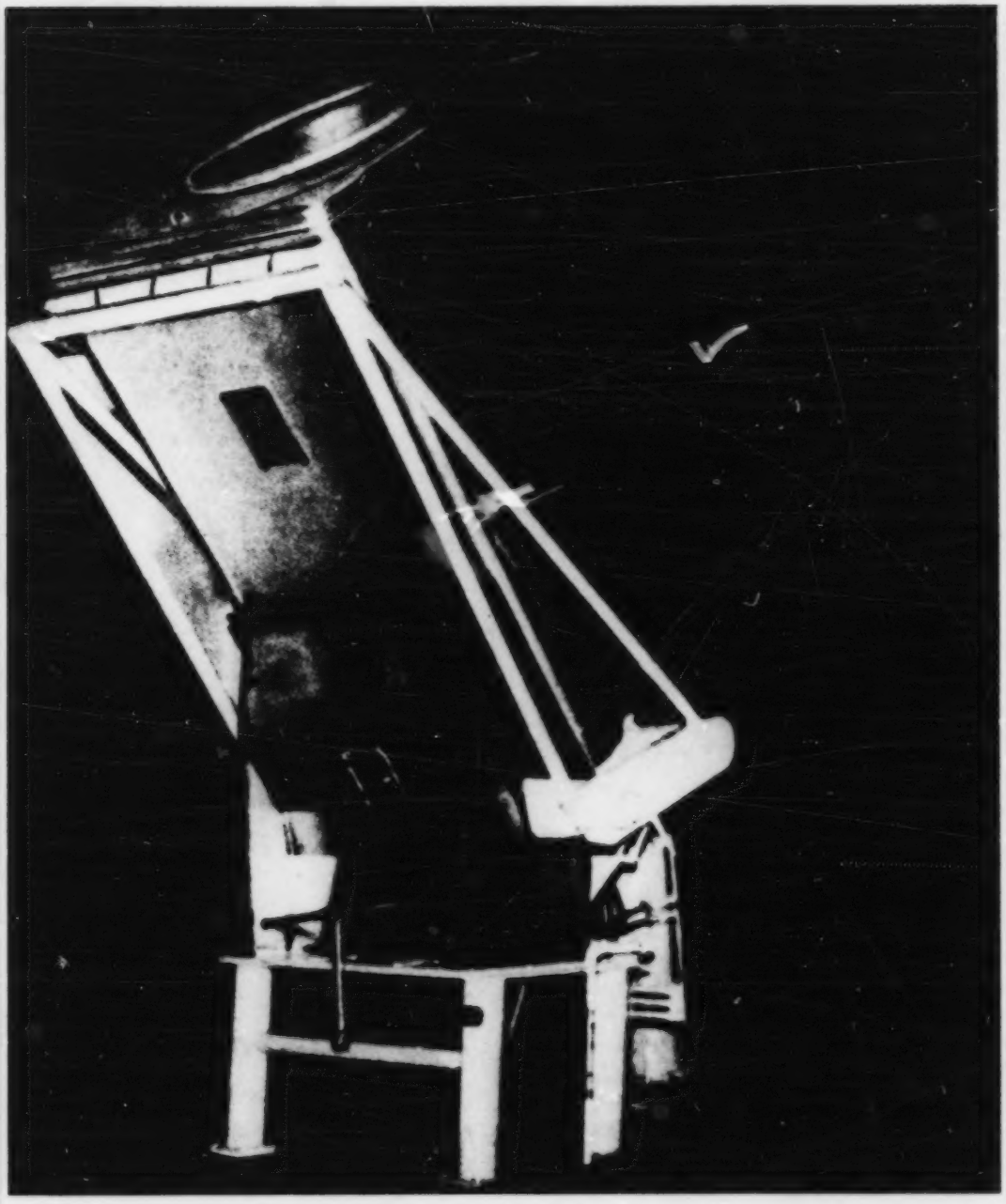

Figure 5. Bulk Material Container and Unloading Device

## 6. ENVIRONMENTAL ASSESSMENT

The effects on air and water quality due to the incineration of hazardous wastes on the proposed offshore platform were estimated both near the platform itself and at the nearest point on shore. The emissions considered were gaseous emissions from the incinerator stack (with or without an effluent scrubber), and water effluents injected into the ocean from the quench and scrubber operations. To estimate pollutant concentrations near the platform and on shore (100 km distant), a Gaussian dispersion analysis was used for both the gaseous plume and quench and scrubber liquids. Plume touchdown impacts were determined by a conservative semi-empirical analysis considering a unit volume (1 $m^3$) of ocean traveling at a low rate underneath the centerline of the plume touchdown. Important parameters of the models were varied to determine environmental effects.

The results discussed in this section are rough estimates aimed at evaluating the feasibility of the incineration scheme. The analysis presented is limited by 1) a paucity of information on meteorological and marine data for the specific site, and 2) by deficiencies in the analytical tools for modeling the dispersion in the air of pollutants emitted over a body of water and the impact of plume touchdown on water quality.

One of the wastes considered in the analyses was a chemical manufacturing waste consisting of a mixture of chlorinated hydrocarbons containing 62.6% chlorine, which is near the practical limit for undiluted incineration while maintaining a destruction efficiency of 99.99%, and thus represents a worst case for the pollutant HCl. The case for PCB pollution was estimated by selecting a waste containing 30% PCB*.

The actual impact estimates were based on three pollutant species: HCl, $SO_2$, and PCB. Results for the worst case conditions are presented in Table 3 and discussed in the following subsections.

*This PCB content is consistent with meeting the existing sea water quality criteria (Reference 4) under worst case meteorological conditions.

TABLE 3. PREDICTED "WORST CASE" POLLUTANT CONCENTRATIONS FROM OFFSHORE PLATFORM INCINERATOR

| Pollutant | Air Quality Concentrations 100 km from platform (without scrubber) | Water Quality Concentrations at Plume Touchdown $10^5$ sec. contact time (without scrubber) | Water Quality Concentrations in Scrubber/Quench Effluent Plume 24 m from discharge point |
|---|---|---|---|
| HCl | 85.2 $\mu g/m^3$ | 0.58 $g/m^3$ | 410 $g/m^3$ |
| $SO_2$ | 3.2 $\mu g/m^3$ | 0.023 $g/m^3$ | 20 $g/m^3$ |
| PCB | 0.004 $\mu g/m^3$ | 0.019 $mg/m^3$ | 6 $mg/m^3$ |

## 6.1 AIR QUALITY IMPACTS

The air quality modeling effort used a standard Gaussian diffusion and transport model to evaluate changes in pollutant concentration as a function of various meteorological and operating parameters. The calculations focused on assessing the impacts on the nearest point of land, approximately 100 km north-northwest of the platform.

Air quality concentrations estimated for the three pollutants are (Table 3) are well below established or suggested criteria, even without stack effluent scrubbing (Reference 1). Parametric analysis was performed for three wind speeds (3.1, 5.14, and 7.7 meters/sec.) and for the two stability classes "D" and "E". The result of this analysis, stated qualitatively, are as follows:

- Increasing the ambient temperature from average winter to average summer temperatures has no noticeable impacts on concentrations.
- Increasing wind speed decreases peak ground level concentrations and shifts the peak closer to the source.
- Increasing stack height decreases the peak ground level of concentration and shifts the peak farther from the source.
- A more stable atmosphere decreases the peak concentration and shifts the peak further downwind. However, as one progresses

downwind from the point of peak concentration, a more stable atmosphere gradually yields higher concentrations.

- Reducing stack gas temperature increases the peak concentrations and shifts the peak closer to the source.

## 6.2 WATER QUALITY IMPACTS

Operation of the incinerator may affect water quality in the vicinity of the platform by stack emissions entering the aquatic environment (i.e., "plume touchdown") and by direct effluent from the quench and scrubber systems. A methodology to estimate transfer of pollutants across the air-water interface and a dynamic model to estimate the direct effluent concentrations under various conditions have been developed.

The overall impact on the water quality will depend on contributions from both the plume touchdown and the direct effluent. The highest concentration from plume touchdown will occur either at about 10,000 meters or very close to the platform, depending on whether the current is flowing in the same or opposite direction as the wind. Theoretically, the latter case will be the worst, because the highest concentration in each case will sum together. However, the values from the plume touchdown analysis are much lower than those due to the direct effluent, and become negligible in comparison, as indicated in Table 3.

### 6.2.1 Plume Touchdown

Mass transfer takes place from the plume to the water; however, the width of the plume and the depth of water affected are not easily identified. The maximum pollutant concentration was estimated by evaluating a one meter cube of water traveling directly under the centerline of the plume at a velocity of 10 cm/sec. The cube was assumed to exist in a larger volume of homogenous concentration, thus eliminating net transfer of pollutants across the cube's aqueous boundaries. The worst case assumption that wind and current directions remain identical so that the one meter cube of water is directly under the plume centerline for the $10^5$ seconds (nearly 28 hours) required to travel 10,000 meters from the platform at a low current velocity of 10 cm/sec is extremely conservative. However, this case is used to demonstrate that environmental quality criteria can be met even with obviously unlikely conditions because no

realistic values can be calculated without sufficient meteorological data for the specific site.

In performing the calculations, meteorological and stack height conditions resulting in a maximum distribution of air pollutants available for transfer across the ocean surface were chosen. Actual water quality concentrations of the pollutants are expected to be considerably lower than the worst case values listed in Table 3.

Major conclusions of the worst case analysis are as follows:

- Concentrations of HCl and $SO_2$ are not high enough to seriously alter pH or chlorinity. Secondary effects such as BOD response are not considered.

- PCB concentrations due to plume touchdown are less than the sea water quality criteria of 0.20 $mg/m^3$ maximum and 0.024 $mg/m^3$ as a 24-hour average (Reference 4) without scrubbing. From 50% to as much as 85% of the PCB emissions may be removed by using the scrubbing system provided. Water quality concentrations may also be lowered by dilution of the waste, by reduction of the feed rate, and/or by limiting continuous PCB incineration periods to less than 24 hours each.

- Plume concentrations fall off rapidly beyond 10,000 meters from the platform, thus no significant amount of material is transferred from the plume to the ocean beyond that distance.

6.2.2 Liquid Effluent from Quench and Scrubber Systems

The model used to estimate dispersion of the scrubber/quench effluent treated the liquid effluent as a plume emanating from a point source. Initially, mixing is accomplished largely through shear forces acting on the plume walls. Later, ambient turbulence becomes the dominant mixing force. The essential purpose of the model is to calculate dilution factors for a number of points along the centerline of the plume so that actual physical parameters can be determined. Model parameters which were varied included the two modes of operation (quench and scrubber), seasonal ocean conditions (summer and winter), and varying water currents (high and low velocity) under otherwise nominal conditions. Eight sets of assumptions were generated by varying three parameters: quench only or scrubber and quench effluent, summer or winter water density stratification, and high (50 cm/sec.) or low (10 cm/sec.) velocity ocean current.

Concentrations of chloride ion, sulfite ion, and unburned hydrocarbon at 24 meters from the discharge point were compared for each of the eight cases. Based on the estimated concentrations, the worst case was determined to be the case where scrubber effluent was discharged under conditions of winter density stratification and high surface-current velocity. Under these conditions, PCB concentrations in the scrubber/quench effluent plume (Table 3) could significantly exceed the suggested water quality criteria limits (Reference 4) of 0.20 $mg/m^3$ maximum and 0.024 $mg/m^3$ for a 24 hour average. For incineration of wastes containing high concentrations of PCBs, an activated carbon effluent water treatment system will be provided, as described in Section 4.

Once the worst-case situation was chosen, three other parameters (depth of injection, angle of injection, and turbulence level) were varied to determine their effect on the given situation. This analysis was the basis for the recommendations concerning design of the outfall pipe.

Major conclusions from the parametric analysis are as follows:

- High currents give higher concentrations in the wintertime.
- Low currents give higher concentrations in the summertime.
- For the waste studied, the worst case occurs with the scrubber operating in the wintertime and high current.
- These results may differ for effluents of different density.
- Lowering point of discharge has no effect on absolute concentrations but increases the depth at which impact occurs.
- Angling discharge pipe from vertical lowers overall concentrations. Effects of 45° and 90° angles are essentially the same.
- High ocean turbulence improves mixing in the far field but may inhibit mixing in near field.

Major recommendations are as follows:

- Increase exit velocity of quench to minimize near field temperature effects.
- Angle pipe outlet 45° in direction of current to increase plume depth.
- Increase discharge pipe length if additional plume depth is required.

## 6.3 MARINE IMPACTS

A marine environmental assessment was provided to EPA by TerEco Corporation. Eleven specific criteria for selection of environmentally acceptable sites for ocean dumping are presented in Part 228.6 of the 1977 regulations (11 January 1977 Federal Register) governing ocean dumping. Results of the application of these criteria to the establishment of the platform incinerator are summarized in Table 4.

TABLE 4. APPLICATION OF EPA SPECIFIC CRITERIA FOR SELECTION OF OCEAN DUMPING SITES

| CRITERION | RESPONSE |
|---|---|
| 1. Geographic position, depth of water, bottom topography, and distance from coast to coast. | Distance of the platform from shore ensures no serious impact on the coastal zone. Water depth ensures effective dilution of discharge contaminants. No other platforms in vicinity. |
| 2. Location in relation to breeding, spawning, nursery, or passage areas of living resources in adult or juvenile phases. | The platform is located generally seaward of such areas. |
| 3. Location in relation to beaches and other amenity areas. | All such areas are at least 100 km shoreward of the platform thus it is unlikely that any will be impacted. |
| 4. Types and quantities of wastes proposed to be disposed of, and proposed methods of release, including methods of packing the waste, if any. | It is proposed to incinerate organochlorine residues from the manufacture of various chemical products. Principal combustion products will be HCl, $SO_2$, $CO_2$, and $H_2O(g)$. If scrubbers are used, scrubber effluent containing combustion products will also be discharged. |
| 5. Feasibility of surveillance and monitoring. | Excellent, since the platform is isolated from other structures and is reasonably accessible from shore |
| 6. Dispersal, horizontal transport and verical mixing characteristics of the area, including prevailing current direction and velocity, if any. | Location in the transition area between open Gulf and shelf waters make it almost certain that discharged contaminants will be diluted below detectable limits. |
| 7. Existence and effects of current and previous discharges and dumping in the area (including cumulative effects). | None, except for those involved with installation and operation of the oil platform during drilling activities. |
| 8. Interference with shipping, fishing, recreation, mineral extraction, desalination fish and shellfish culture, areas of special scientific importance and other legitimate uses of the ocean. | Little or no effect when the platform is properly operated. |
| 9. The existing water quality and ecology of the site, as determined by available data or by trend assessment or baseline. | Water quality of the ocean surrounding the platform is normal. |
| 10. Potentiality for the development or recruitment of nuisance species in the disposal site. | Does not apply. |
| 11. Existence at or in close proximity to the site of any significant natural or cultural features of nistorical importance. | None. |

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4. "Water Quality Criteria; Availability," Federal Register, Vol. 44, No. 144, Wednesday, July 25, 1979, Notices, pp 43691.

EPA-600/2-81-044a
March 1981

# Offshore Platform Hazardous Waste Incineration Facility: Feasibility Study Summary

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Contract No. 68-02-3174
Work Assignment No. 19, TSA 3-7

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